LA-UR-02-7093

Potential Radiological Dispersal Device (RDD) Threats and Associated Technology

Evelyn Mullen, Greg Van Tuyle, and Rob L. York

Los Alamos National Laboratory

Assessing RDDs as Threats

- Ongoing process, attempting to anticipate intelligent use of RDD and assessing terrorist trends
- Millions of radiological sources are available, but a large majority of sources (e.g., nuclear medicine diagnostic dosages) are relatively harmless
- Usage of an RDD may trigger panic out of proportion of true risk to human health and safety
- Two-tier strategy possible:
  - For minor sources, public education & response crucial
  - For large sources, need to tighten controls, detect during transport, and prepare appropriate responses

Two Broad Categories of Candidate Radiological Materials

- Materials that are largely under controls at a limited number of sites:
  - Nuclear weapons materials – excess/retired or waste streams
  - Nuclear power related materials – fresh or spent fuel; wastes
- Radiological materials under limited controls and at numerous locations
  - Industrial, medical, or other applications
  - Many are used world-wide, under variable regulation
- Activity levels and potential radiological dose hazards vary by <u>many</u> orders of magnitude

Additional Considerations Regarding Materials for Use in RDDs

<u>Detectibility</u>

- Unshielded source materials can be detected, in general, if sufficient quantity
- Some materials are easier to shield than others

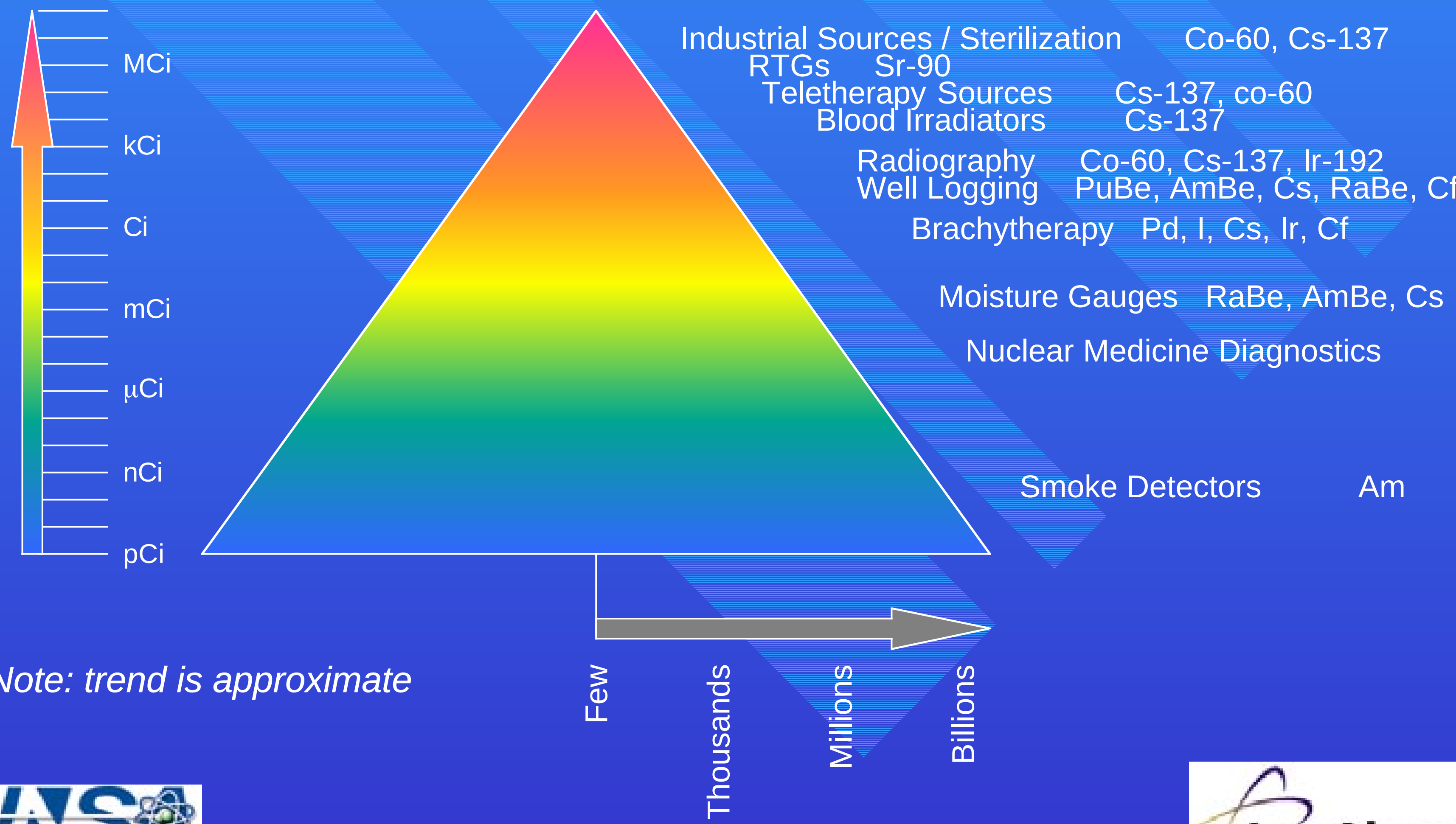
<u>Dispersibility</u>

- Some materials can be dispersed more effectively than others

<u>Decontamination</u>

- Some materials could pose greater challenges for decontamination

Small & Insignificant Sources Greatly Out-Number Large & Hazardous Sources



Note: trend is approximate

Doses Relative to Co-60 for Key Isotopes

α-emitting transuranics require special consideration

- Doses from most isotopes of interest don't differ greatly from Co-60
- Transuranic α-emitters provide much greater dose via ingestion or inhalation

Rem per Curie per hour at 1 meter

Committed dose equivalent over 50 years

Isotope	Half-life	RHM	CDE Ingest	CDE Inhale	RHM/Co	Ingest/Co	Inhale/Co
Co-60	5.3 yr	1.37	26900	219000	1.0	1.0	1.0
Cs-137	30.1 yr	0.38	50000	31900	0.3	1.9	0.1
Ir-192	74 d	0.59	5740	28100	0.5	0.2	0.1
Sr-90	29.1 yr	0.00	142000	1300000	0.0	5.3	5.9
Pu-238	88 yr	0.08	3200000	392000000	0.1	119.0	1790.0
Ra-226	1600 yr	0.01	1320000	8580000	0.0	49.1	39.2
Am-241	433 yr	0.31	3640800	444000000	0.2	135.3	2027.4
Cf-252	2.6 yr	0.04	1084100	136900000	0.0	40.3	625.1
Pd-103	17 d	0.23	788.1	1568.8	0.2	0.0	0.0
I-125	60.1 d	0.27	38480	24161	0.2	1.4	0.1

Basis: Handbook of Health Physics & Radiological Health [Shleien]

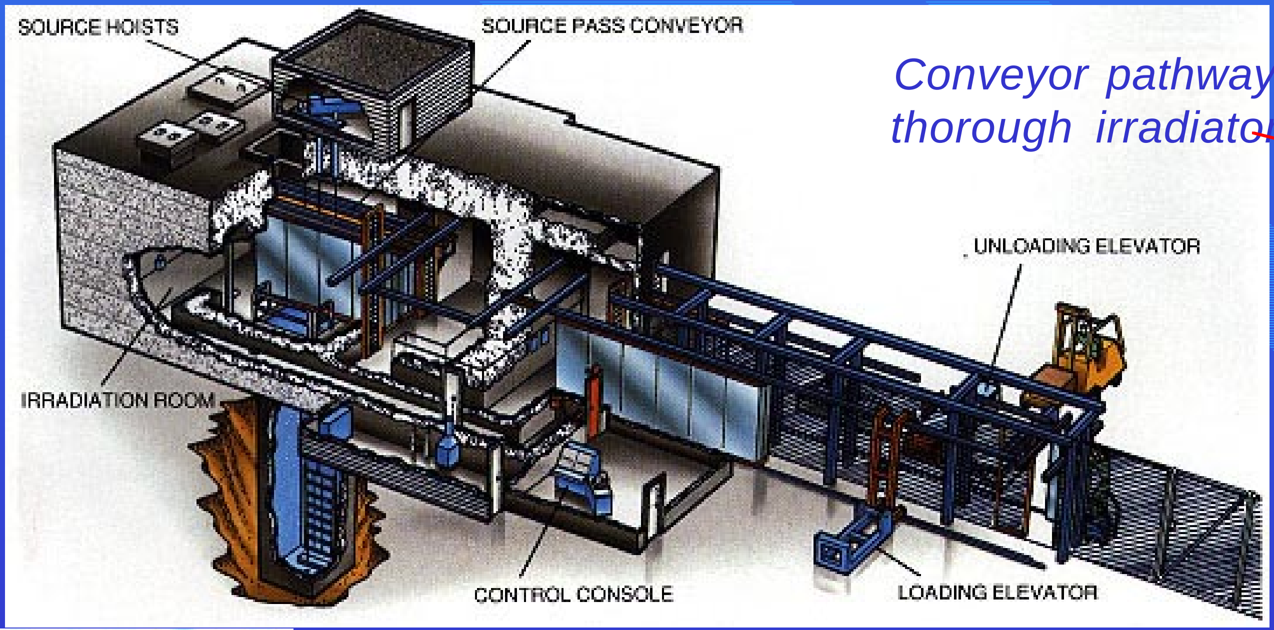
NNSA

Los Alamos

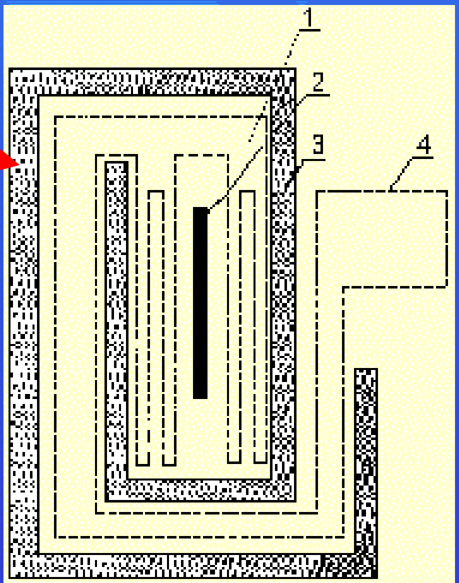
Industrial Irradiators *(Sterilization sources)*

Large stationary irradiation facilities may utilize mega-Curies of Cesium or Cobalt. They require extremely high levels of shielding. Sources are arranged in arrays and often stored in water pools to provide both thermal control and shielding.

Boxes of medical supplies, readied for radiation



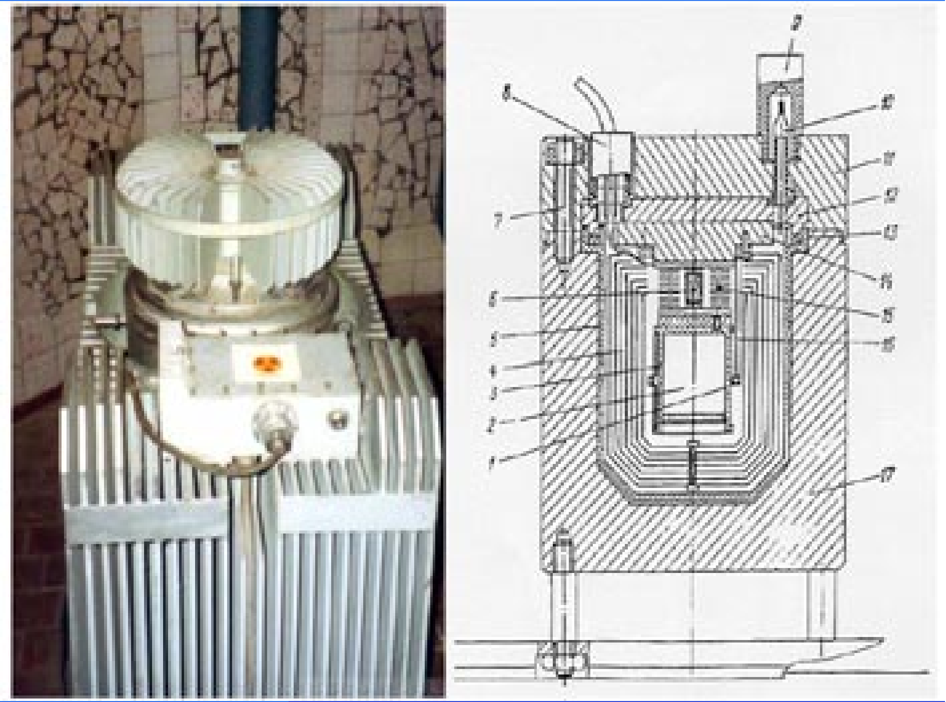
Conveyor pathway thorough irradiator



Schematic of industrial irradiator

Radioisotope Thermal-Electric Generators (RTG)

- Power Sources for Remote Locations, usually based on Sr-90 or Pu-238
  - Some Sr-90 sources are as large as 400 kCi (10^{16} Bq)
- Reduction in RTG availability could include:
  - Recovering retired units and transferring to waste sites
  - Implementing alternate technologies where practical
  - Implementing technologies to alert as to RTG displacement and alternate location



Sr-90 Radioisotope Thermal-Electric Generators

Los Alamos

Teletherapy Sources

Medical Teletherapy Sources: Corrosion free nickel plated cobalt-60 pellets contained in low carbon steel capsules. The capsules are double encapsulated to ensure a completely sealed and contained radiation source. The diameter of the sources is up to 2.0 cm. Source strength in some of these teletherapy units is up to 15,000 Ci. Usually, the sources are replaced every 5 to 7 years. Average replacement and downtime for renewing the sources is about 48 hours.

To the right is a source capsule of the type that was used in medical teletherapy units up until the 1980s. The gamma rays emitted by the source were used to treat cancer. The radioactive source material, over 1000 curies of cobalt-60 or cesium-137, was contained in a doubly encapsulated stainless steel cylinder approximately one inch in diameter. The rest of the capsule (approximately two inches in diameter) consisted of a tungsten alloy housing threaded to fit into the teletherapy unit.

Medical Teletherapy Unit Typical of Those Used in Central and Eastern Europe

Medical Teletherapy Unit, Vietnam

Los Alamos

Possible Steps to Minimize the RDD Threat

1. Control/Secure/Track Materials of Concern for use in RDDs

   Add or Increase security for large source sites, including waste sites

   Develop and deploy alternate technologies, e.g., electron accelerators

   Utilize technologies for tracking large remote sources such as RTGs

   Support orphan source recovery and disposal programs, e.g., IAEA

2. Increase Likelihood that Nuclear Smuggling Attempts Detected

   Improve technologies: better/cheaper/simpler/more reliable/…

   Develop mobile search and response teams: discover & respond to use

   Extend search & response efforts to include international community

3. Prepare Response to Use of RDDs

   Emergency response – plan appropriate actions & communications

   Decontamination technologies and strategies needed

NNSA

Los Alamos

Potential Interdiction Concerns: Distance and Shielding

- Approximately 90% of cargo worldwide moves by container, much of it stacked dozens of stories high on huge transport ships
- 200 million cargo containers are transported between the world's seaports each year, constituting the most critical component of global trade.
- In the United States, nearly half of all incoming trade by value – about 46% -- arrives by ship, and most of that is in sea containers.

Note: Data from US Customs

Interdiction and Response

1 **DETECT**

- A radiation portal monitor or search instrument **DETECTS** the presence of radiation.
- Opportunities for detection exist at border crossings and ports
- For example: US Customs targets containers of concern and radiographs them looking for anomalies

2 **LOCATE**

- The hand-held search instrument **LOCATES** the source of the radiation.

3 **IDENTIFY**

- The isotope identification instrument **IDENTIFIES** the source of the radiation

Examples of Portals

- Need to have a system of integrated detectors
- Focus on control points where traffic can be funneled through
- Training of inspectors and maintenance of the system is vital for long-term performance

Train Portal Monitor at the Astrakhan Seaport on the Caspian Sea

NNSA

Los Alamos

Examples of Hand-Held Isotope Identifiers and Search Instruments

Neutron-gamma hand held with isotope identification

Parameters That Influence the Sensitivity of Monitors

- False alarm rate
- Radiation signal intensity
- Background intensity
- Detector geometry
- Monitoring time
- Vehicle, container, and body shielding

NNSA

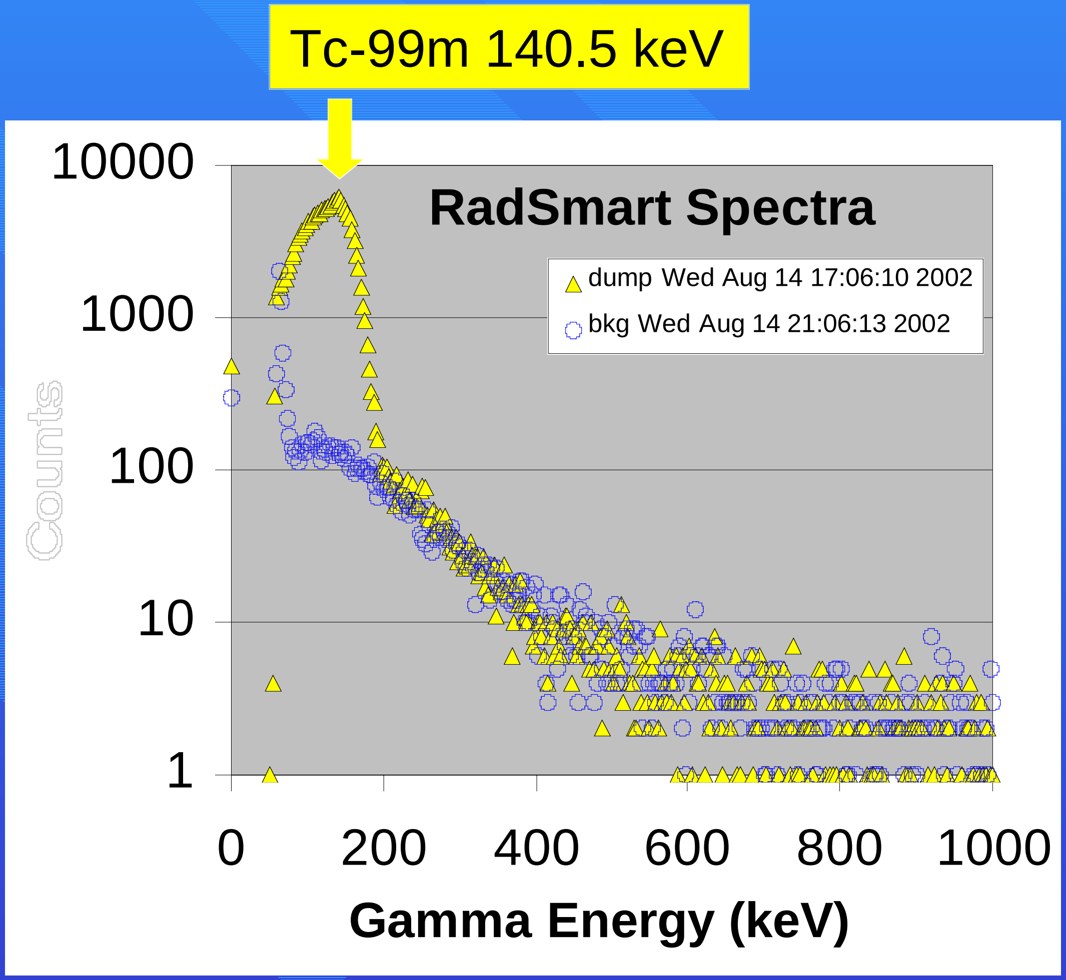
Los Alamos

Second Line of Defense Experience in Russia

- Innocent alarms are the biggest problem
- Neutron detectors are necessary for SNM detection
- Slightly reduced sensitivities to reduce false alarm rates are practical
- The importance of training and maintenance…

Example of Potential False Alarm from Radioisotope Treatment

- Garbage truck tripped radiation sensor at Los Alamos landfill.
- Found diaper containing Tc-99m, a common medical radioisotope. (RAP Region 4)



Expert Advice - Triage

- Process needs to collect enough data to assess the appropriate response
- Data collected by first responder
  - Radiation data (neutron and gamma)
  - Radiological data (alpha and beta)
  - Visual data (digital photos)
- Automated/easy telemetry to experts for expert analysis

NNSA

Los Alamos

Conclusions

- Steps can be taken to minimize the RDD threat worldwide, but it is not likely that we can eliminate the threat
- Radiation portal monitors can be an effective tool to combat the illicit movement of nuclear material
- Planning needs to take place for recovery from an RDD event
  - Communications
  - Decontamination